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**Active-matrix liquid crystal display - has two thin film transistors provided in vicinity of transparent electrodes connected to gate and source lines**

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The device comprises an insulating substrate (1) carrying a number of transparent electrodes (2) in a matrix fashion to form a number of pixels. Two thin film transistors (3), each having a drain, source and gate electrode, are laid close to the transparent electrodes with the drain electrode connected to the transparent electrode.

A common gate electrode line (G) is provided for each row of the transparent electrodes and at right angles to them are source electrode lines (S) for each column to provide connections to external circuits. A method for testing is disclosed.

ADVANTAGE - Thin film transistors in the display can be inspected without damage with reduced production time and cost.

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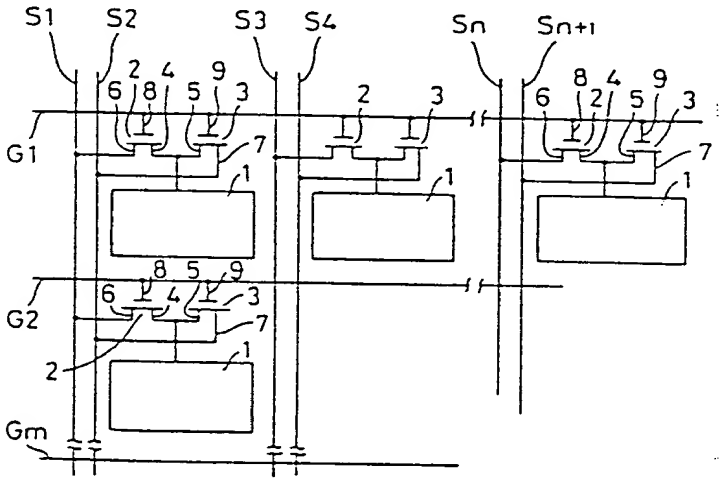

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## (54) Liquid crystal display device.

(57) A liquid crystal display device comprising an insulating substrate, a plurality of transparent electrodes disposed on the insulating substrate in a matrix fashion to form a plurality of pixels, at least two thin film transistors disposed in the vicinity of each of the transparent electrodes on the insulating substrate, each the thin film transistor having a drain electrode, a source electrode and a gate electrode, in which the drain electrode is connected to the transparent electrode, a gate electrode line for each line or column of the transparent electrodes disposed on the insulating substrate in the vicinity thereof, each the gate electrode of the thin film transistors connected to each of the transparent electrodes of the line or column being connected in common thereto, and source electrode lines for each column or line of the transparent electrodes disposed on the insulating substrate in the vicinity thereof and at a right angle to the gate electrode line, the number of the source electrode lines being equal to the number of the thin film transistors connected to one transparent electrode, in each the source electrode of the thin film transistors connected to each the transparent electrode of the column or line being connected respectively thereto in a manner capable of connection to an exterior circuit.

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## BACKGROUND OF THE INVENTION

The present invention relates to a liquid crystal display device, specifically to an active-matrix liquid crystal display device which provides a specific connection structure in a plurality of thin film transistors for driving pixel which they themselves are connected to one of the transparent electrodes which forms the pixel.

In a conventional active-matrix liquid crystal display device, as shown in Fig. 4, one thin film transistor b for each driving pixel is connected to each of the transparent electrodes (Indium Tin Oxide) arranged in a matrix fashion to form each pixel. A drain electrode c of each thin film transistor b is connected to each transparent electrode a, and each source electrode d is connected to a common source electrode line e on each column of the matrix, and each gate electrode f is connected to a common gate electrode line g on each row of the matrix, respectively. The above-described transparent electrodes a, thin film transistors b, source electrode lines e on each column, and gate electrode lines g on each row are formed on an insulating sub strate h.

In the liquid crystal display device having the above-mentioned structure, the characteristic inspection of the thin film transistor b is conducted by a bringing a needle-shaped probe into contact (pressure contact) with the transparent electrode a of the pixel which is connected to the drain electrode c of the thin film transistor b, and a voltage is applied to the source electrode d, which is not less than a threshold voltage applied to the gate electrode f, and the resulting current flow into the transparent electrode a is measured.

However, with the inspection method described above, it is difficult to test all of the thin film transistors because of the presence of narrow pitches of the transparent electrodes a and because of the large number of pixels. In addition, the contact of the needle-shaped probe and the transparent electrode of the pixel is prone to damage the thin film transistor b, and in the case of a color liquid crystal display device, in inspecting the characteristics of the thin film transistor b, a defect in the pixel has been judged to have occured by performing black-and-white display, and therefore the manufacturing cost has been high.

Also, in the Japanese Patent Laid-Open Publication No. 61(1986)-249078, a matrix-type display device is described wherein two thin film transistors are disposed for one pixel electrode, and a bypass is disposed in the source electrode line, and either of the thin film transistors is utilized for a method of correcting a defect caused by a short-circuit between the gate electrode line and the source electrode line, a short-circuit between the source electrode and the drain electrode, a short-circuit between the gate electrode and the drain electrode, or a breaking between the drain electrode and the pixel electrode, and thereby the reliability of the display device can be secured.

However, in the matrix-type display device as shown in the above-mentioned patent publication, when a defective thin film transistor is separated from the pixel electrode by etching or laser cutter, this results in greater time lost and higher costs required for inspection and correction especially in mass-production.

The present invention has been achieved in light of the above-mentioned circumstances, and has as its purpose to provide a liquid crystal display device which will allow characteristic inspection of the thin film transistor for driving pixel without damaging the thin film transistor.

## SUMMARY OF THE INVENTION

The present invention relates to a liquid crystal display device comprising (1) an insulating substrate, (2) a plurality of transparent electrodes disposed on the insulating substrate in a matrix fashion to form a plurality of pixels, (3) at least two thin film transistors disposed in the vicinity of each of the transparent electrodes on the insulating substrate, each thin film transistor having a drain electrode, a source electrode and a gate electrode, in which the drain electrode is connected to the transparent electrode, (4) a gate electrode line for each line or column of the transparent electrodes disposed on the insulating substrate in the vicinity thereof, each gate electrode of the thin film transistors connected to each of the transparent electrodes of the line or column being connected in common thereto, and (5) source electrode lines for each column of line of the transparent electrodes disposed on the insulating substrate in the vicinity thereof and at a right angle to the gate electrode line, the number of the source electrode lines being equal to the number of the thin film transistors connected to one transparent electrode, in each the source electrode of the thin film transistors connected to each the transparent electrode of the column or line being connected respectively thereto in a manner capable of connection to an exterior

circuit.

The transparent electrode in the present invention is preferably an indium tin oxide film which is formed by a physical method such as electron beam evaporation, resistance heat evaporation or sputtering, or by a chemical method such as spraying or the CVD method.

Also, for the thin film transistor, a semiconductor material such as polycrystalline silicon, amorphous silicon, Te or CdSe is used, and may be fabricated by a conventional method in this field.

Furthermore, the gate electrode lines and the source electrode lines are preferably formed with metals such as Ta, Mo, Ti or Al.

The gate electrode lines are preferably disposed in the vicinity of the transparent electrodes in parallel to the row direction, and the source electrode lines are preferably disposed in the vicinity of the transparent electrodes in parallel to the column direction, respectively. Here, the word vicinity as is commonly understood in the field refers to the necessary spacing between the transparent electrodes and the gate and source electrode lines.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a fragmental structural schematic view showing a wiring structure of an embodiment in accordance with the present invention.

Fig. 2 is an electric wiring diagram for explaining a method of inspecting the characteristics of a thin film transistor of the embodiment.

Fig. 3 is a fragmental structural schematic view showing the final connection structure of the source electrode lines of the embodiment.

Fig. 4 is a partial structural schematic view of prior art.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 1, numeral 1 designates transparent electrodes, which are disposed on an insulating substrate (not illustrated) in a matrix fashion, for example, a glass substrate to form a plurality of pixels.

For the transparent electrode 1, an ITO (Indium Tin Oxide) film is preferable.

Connected to each transparent electrode 1, are each of the drain electrodes 4 and 5 and a plurality of, for example, two thin film transistors 2 and 3 for the driving pixel made and disposed on the insulating substrate by a conventional method in this field. Also, source electrodes 6 of the thin film transistors 2 in the direction of the same column are connected to one common source electrode line S1, and source electrodes 7 of the thin film transistors 3 are connected to a source electrode line S2. Similarly, the respective thin film transistors 2 and 3 in the column direction of the n-th column are connected to source electrode lines Sn and Sn + 1, respectively. This means that the number of source electrode lines is equal to the number of thin film transistors connected to one transparent electrode which are formed on the insulating substrate in a manner capable of connecting the respective source electrodes 6 and 7 to an exterior circuit which will be described later. Each of the source electrode lines S1, S2, ..., Sn, Sn + 1 is disposed in the vicinity of a column constituted with the respective transparent electrodes 1 in parallel to the direction of that column, with the width separation preferably about 10 - about 15 μm.

Furthermore, gate electrodes 8 and 9 of the respective transistors 2 and 3 arrayed in the direction of the same row are connected to one of the gate electrode lines G1, G2, ..., Gm which are disposed on each row in the vicinity of the respective transparent electrodes 1 which run parallel to the gate electrode lines. Accordingly, the respective source electrode lines S1, S2, ..., Sn, Sn + 1 are orthogonal to the respective gate electrode lines G1, G2, ..., Gm.

The respective thin film transistors 2 and 3 are formed between the transparent electrodes 1 of the res pective rows and the gate electrode lines G1, G2, ..., Gm of the respective rows.

Next, description is made on a method of inspecting characteristics of the thin film transistors 2 and 3 in this embodiment in reference to Fig. 2.

As shown in Fig. 2, a voltage for driving thin film transistors is applied from an exterior circuit to the gate electrode line G1 which is connected to the gate electrodes 8 and 9 of the thin film transistors to be tested. At this location on the first column, a power source 11 of a voltage of +V is connected to the source electrode line S1 through an external switch 10. Then, an amperemeter 12 is connected to be the source electrode line S2.

In the above-mentioned state, if the thin film transistors 2 and 3 are normal, a current flows from the source electrode 6 of the thin film transistor 2 to the drain electrode 4, and further flows from the drain electrode 5 of the thin film transistor 3 to the source electrode 7. Accordingly, the amperemeter 12 connected to the source electrode line S2 should indicate a predetermined current value. In reverse to the above-mentioned, if either or both of the thin film transistors 2 and 3 are defective, the amperemeter 12 does not indicate the predetermined current value, and therefore the abnormal (defective) thin film transistors 2 and/or 3 are de-

tected.

Similarly, testing the thin film transistors 2 and 3 of the first column can be conducted by applying the voltage for driving thin film transistors applied to the gate electrode line G1 sequentially to the gate electrode lines G2, ..., Gm from the above-mentioned state of connection in a switching-over fashion. Furthermore, the power source 11 and the amperemeter 12 are connected to the respective source electrode lines S3, S4, ..., Sn, Sn + 1 in a sequential switching-over fashion, and as mentioned above, the voltage for driving thin film transistors is applied to the gate electrode lines G1, G2, ..., Gm in a sequential switching-over fashion, and thereby the characteristic inspection of all the thin film transistors 2 and 3 can be conducted.

As shown in Fig. 3, after completing the characteristic inspection, two of the source electrode lines S1, S2, S3, S4, ..., Sn, Sn + 1, which form a pair on each column, are short-circuited, and thereby two thin film transistors 2 and 3 for the driving pixel are connected to one transparent electrode.

In addition, in the above-mentioned embodiment, the case with two thin film transistors is described, but the number of the thin film transistors may be three or more, and in this case, the drain electrodes of the respective transistors are connected to the transparent electrode, and the source electrodes are connected separately to the source electrode lines. Then, in conducting the characteristic inspection of the thin film transistor, the voltage is applied to one source electrode line, and the amperemeters are connected to the rest of the source electrode lines, and thereby characteristics of a plurality of thin film transistors connected to one transparent electrode can be inspected by the same method.

Therefore, in accordance with the present invention, the testing of the thin film transistor for the driving pixel can be easily conducted without damaging the thin film transistor. If the characteristics of even one or more of the thin film transistors connected to one transparent electrode is at a certain level or greater, a liquid crystal display device can be made which does not produce a point defect and does not diminish the quality of its display.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention.

There are described above novel features which the skilled man will appreciate give rise to advantages. These are each independent aspects of the invention to be covered by the present application, irrespective of whether or not they are included within the scope of the following claims.

## Claims

1. A liquid crystal display device comprising an insulating substrate,

a plurality of transparent electrodes disposed on the insulating substrate in a matrix fashion to form a plurality of pixels,

at least two thin film transistors disposed in the vicinity of each of the transparent electrodes on the insulating substrate, each thin film transistor having a drain electrode, a source electrode and a gate electrode, in which the drain electrode is connected to the transparent electrode,

a gate electrode line for each line or column of the transparent electrodes disposed on the insulating substrate in the vicinity thereof, each gate electrode of the thin film transistors connected to each of the transparent electrodes of the line or column being connected in common thereto, and

source electrode lines for each column or line of the transparent electrodes disposed on the insulating substrate in the vicinity thereof and at a right angle to the gate electrode line, the number of the source electrode lines being equal to the number of the thin film transistors connected to one transparent electrode, in each the source electrode of the thin film transistors connected to each the transparent electrode of the column or line being connected respectively thereto in a manner capable of connection to an exterior circuit.

2. A liquid crystal display device in accordance with claim 1, wherein the transparent electrode is an indium thin oxide film.

3. A liquid crystal display device in accordance with claim 1, wherein the gate electrode lines are provided in the vicinity of the transparent electrodes in parallel to the row direction, and the source electrodes lines are provided in the vicinity of the transparent electrodes in parallel to the column direction.

4. A liquid crystal display device in accordance with claim 3, wherein the transparent electrode is an indium tin oxide film.

5. A liquid crystal display device comprising a plurality of display elements each including a transparent display electrode for controlling the display state of that element, each said electrode being connected to a plurality of source lines by a corresponding plurality of thin film transistors arranged in parallel so as to interconnect when in their conductive states, said source lines, such source lines being arranged to be independently connectable to external test circuitry.

6. A liquid crystal display device according to claim 5 wherein the gate electrodes of said plurality of thin film transistors associated with any given display element are connected to a common gate electrode line.

7. A liquid crystal display device according to claim 5 or claim 6 wherein said display elements are disposed in a matrix fashion of columns and rows and wherein in each column, the display electrodes are connected by their respective pluralities of thin film transistors to a common said plurality of source lines extending along that column, and wherein in each row the pluralities of gate electrodes of the pluralities of thin film transistors associated with the respective display elements are connected to a common gate electrode extending along that row.

FIG. 1

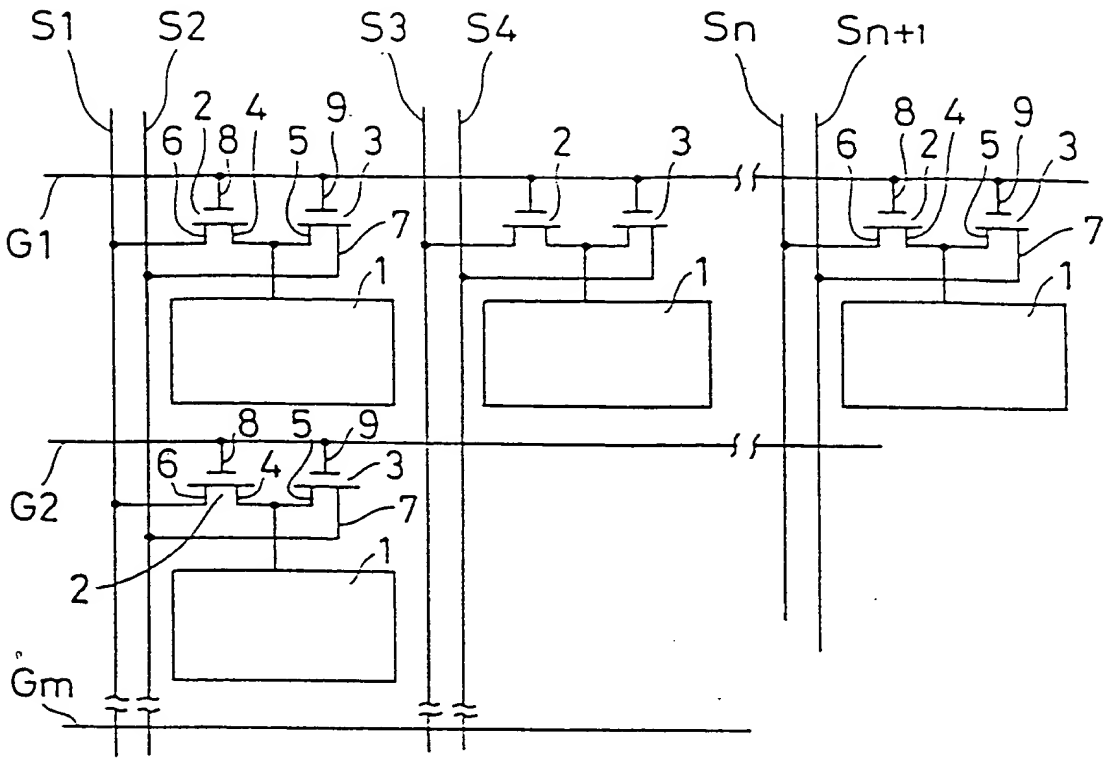
S1
S2
S3
S4
Sn
Sn+1
G1
G2
Gm
1
2
3
4
5
6
7
8
9

FIG. 2

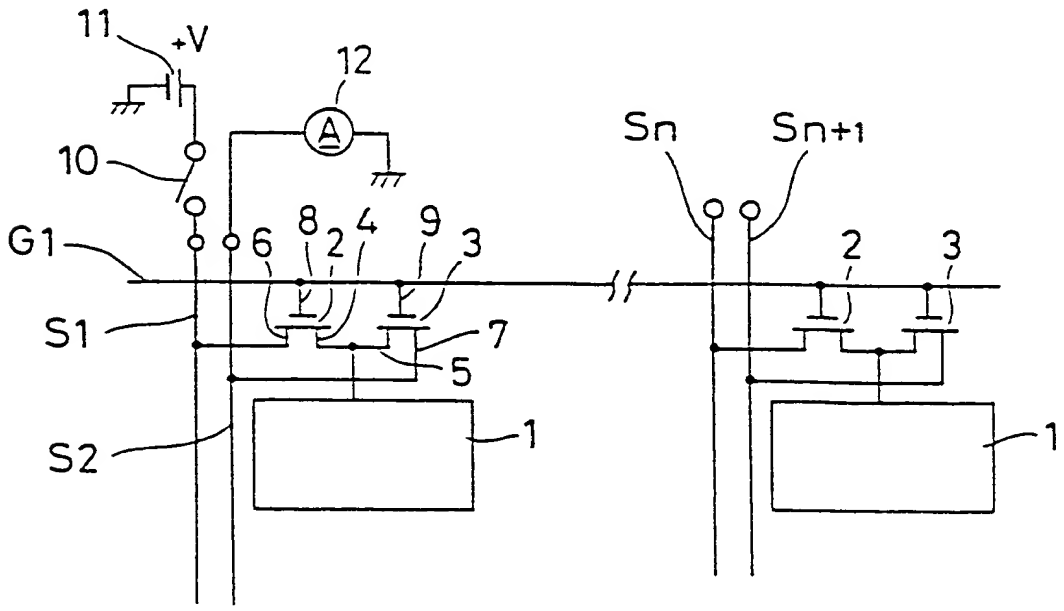
11
+V
12
A
10
G1
S1
S2
Sn
Sn+1
1
2
3
4
5
6
7
8
9

FIG. 3

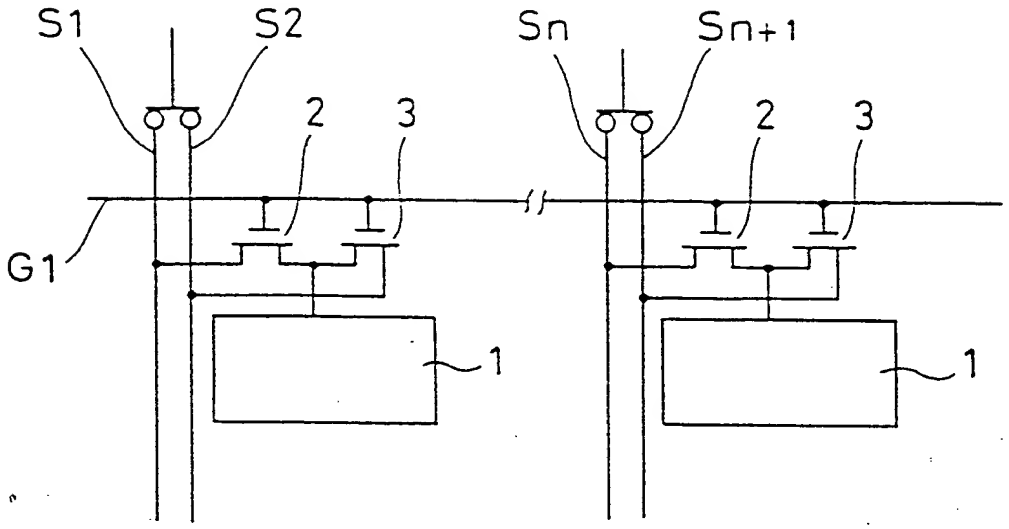


FIG. 4 (PRIOR ART)